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Systemic Joint Hypermobility and Maximum Mandibular Opening

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SYSTEMIC JOINT HYPERMOBILITY AND MAXIMUM MANDIBULAR OPENING

by

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This Independent Study, submitted by Ted D. Thomas in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Chairperson, Physical Therapy)

PERMISSION

Title	Systemic Joint Hypermobility and Maximum Mandibular Opening
Department	Physical Therapy
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ABSTRACT

The purpose of this study was to determine whether people with generalized joint hypermobility also demonstrate hypermobility at the temporomandibular joint. In addition, an attempt was made to determine the relationship between general joint mobility, gender, temporomandibular joint symptoms, and oral parafunction.

Forty-seven physical therapy students worked in pairs under supervision to measure and record: 1) the Beighton hypermobility criteria, 2) maximum mandibular range of motion, and 3) a questionnaire of temporomandibular joint dysfunction and oral parafunctional habits.

The mean Beighton score for males was 1.21 and for females 2.14. Twelve out of the forty-seven subjects (15.5%) had a Beighton score greater than or equal to four. The mean maximal mandibular opening for all subjects was 53.68 mm. The mean maximal opening for males was 58.00 and for females 50.75 mm.

The T test for independent samples revealed that males have a greater maximal opening of the mandible ($p = .05$). Calculation of the Pearson coefficient for the variables of mandibular opening, generalized mobility, symptoms, and oral parafunctions revealed a strong correlation between gender and maximal mandibular opening values ($p = .001$). Because of this strong

relationship, a partial correlation was calculated controlling for gender. The adjusted data indicated that generalized joint hypermobility is positively correlated with maximum mandibular opening at the .05 level ($p = .008$). It also revealed that oral parafunctional activities are inversely correlated to maximum opening ($p = .039$).

The results of this study indicate a significant relationship between generalized joint hypermobility and maximum mandibular opening. Further investigation is warranted to determine a standardized system for quantifying generalized joint laxity and to define the clinical criteria for hypermobility of the temporomandibular joint.

CHAPTER I

INTRODUCTION

Joint hypermobility is an important concept in the practice of physical therapy because excessive joint laxity has been implicated in a wide variety of articular complications. In 1967, Kirk et al[1] coined the term "hypermobility syndrome" to describe a group of patients with generalized joint laxity associated with musculoskeletal complaints without objective signs of connective tissue disease. In the last decade, evidence has mounted in support of the hypothesis that the hypermobility syndrome represents a widespread disorder of the connective tissue.[2]

The question of whether the temporomandibular joint is affected by the presence of generalized joint hypermobility has not been adequately addressed. Measurement of mandibular movement is regarded as one of the most objective methods of determining the extent of temporomandibular joint dysfunction. A high degree of correlation has been found between restricted mandibular motion and the various signs and symptoms of temporomandibular joint dysfunction.[3] However, there is no agreement as to what defines mandibular hypermobility, and this may be as detrimental as hypomobility.

The purpose of this study is to determine whether people with generalized joint hypermobility also demonstrate hypermobility at the temporomandibular joint. An attempt will be made to determine the relationship between general joint mobility, gender, temporomandibular joint symptoms, and oral parafunction.

CHAPTER II

LITERATURE REVIEW

Joint laxity has attracted curiosity since time immemorial. Hippocrates made the first known medical reference to familial joint hypermobility when he described the Scythians as "being so loose-jointed that they were unable to draw a bow string or hurl a javelin.[4] It has long been recognized that generalized joint laxity is a feature of several hereditary connective tissue disorders including Marfan's syndrome and Ehlers-Danlos syndrome.[1,2] However, it is only in the last three decades that studies have identified the more subtle patterns of articular hypermobility and their associations with common musculoskeletal disorders.

In 1964, Carter and Wilkinson[5] devised a set of clinical procedures to assess articular mobility. They utilized these criteria to show that children who have congenital hip dysplasia and their first degree relatives tend towards generalized joint hypermobility. Three years later, Kirk, Ansell, and Bywaters[1] incorporated these criteria into their study of isolated joint hypermobility.

Kirk et al[1] coined the term "hypermobility syndrome" to describe a group of patients with generalized joint laxity associated with musculoskeletal complaints without cutaneous or internal signs of connective tissue disease. These authors concluded that hypermobility was common in the general public and is not symptomatic or that the symptoms are self limiting in a majority of people. They also felt that this condition represented the extreme of a wide normal variation in joint mobility rather than a familial connective tissue disease. They postulated that the hypermobility syndrome predisposed patients to premature degenerative joint disease.

A few general observations relevant to hypermobility may be made based upon the few epidemiological studies that have been reported. Mobility for a given joint seems to follow a Gaussian distribution.[6] Within a population, it is those persons whose joint range is more than two standard deviations above the mean (in the 90th percentile) who suffer musculoskeletal symptoms.[1] Hypermobility diminishes markedly throughout childhood (especially between the age of five and ten) and then more slowly during adult life. In men, the decline starts in the mid-twenties, and in women joint laxity continues through the mid-forties.[7] Women generally show a greater joint range than men of the same age.[2,7] Hyperextension is more common on the non-dominant side, and range of motion is invariably less on the dominant side.[8] There is widespread ethnic variation, with Asians showing a greater degree of joint mobility than Blacks, who are in turn more mobile than Caucasians.[2,9] Furthermore, "pauci articular" hypermobility may be more prevalent in otherwise healthy subjects than the generalized variety. One study of 660 music students of all ages revealed that 47% of the men and 78% of the women had at least one hypermobile joint.[7]

Because of the variables noted above, and the different methodologies employed, the prevalence of generalized ligamentous laxity in the general public is hard to determine. The hypermobility syndrome (joint laxity with musculoskeletal symptoms) has been reported as affecting five to seven percent of school children, and four to five percent of adults.[1,10] However, the frequency of generalized joint laxity is undoubtedly higher as the majority of persons suffer no ill effects. Studies have noted an association between articular hypermobility and a number of articular sequelae including ligament rupture, recurrent joint dislocation, joint effusion, nonspecific arthralgias and myalgias, and premature degenerative arthritis.[1,2,5,9,10]

The notion that premature osteoarthritis is a direct complication of the hypermobility syndrome has yet to be proven. This observation is based more upon circumstantial evidence than scientific investigation. However, the prevailing opinion is that the likelihood of developing osteoarthritis is proportional to the degree of hypermobility. This is most clearly demonstrated in the Ehlers-Danlos syndrome where extreme degrees of joint mobility are seen. In one series, sixteen of twenty-two patients over the age of forty years had osteoarthritis in one or more joints.[9]

There are three hypothetical explanations for the development of premature osteoarthritis in hypermobile patients. The first mechanism is joint hypermobility. Synovial joints are constrained from excessive motion by their bony configuration and surrounding soft tissues, primarily the joint capsule and ligamentous structure. When the tensile resistance of these natural restraints is reduced, there is additional mechanical stress on the margin of the articular cartilage, and this cartilage is ill-suited for this load bearing function.[11]

The second theory involves joint instability. Lax joints are more liable to sublux or dislocate in response to the appropriate stimuli. This is commonly seen in the shoulder and patella where recurrent dislocation is thought to be a precursor to osteoarthritis.[11] The biomechanical pathogenesis for osteoarthritis is supported by research utilizing canine models. Lateral instability induced by severing the cruciate ligaments initiated early chemical changes in the articular surface of the knee.[12]

Lastly, defective collagen may be the most important link between hypermobility and its sequelae. It is possible that the particular collagen structure which contributes to generalized joint laxity is identical to that which leads to osteoarthritis. In this hypothesis, generalized hypermobility could be seen as a phenotypic marker of a particular genotype which predisposes to osteoarthritis.[2]

There are a number of studies which identify a wide range of extra-articular tissue abnormalities in hypermobile subjects. Fifty-eight percent of the patients in one series exhibited skin which was thin, soft, hyperextensible, and developed striae.[9] At least two studies have reported an association between mitral valve prolapse and the hypermobility syndrome.[13] Bone fragility may also be present resulting in an increased tendency toward fracture. Stress fractures have been noted in the metatarsal bones, vertebral bodies, and pares articularis of the lumbar spine. Other studies have found an increased incidence of abdominal hernia, varicose veins, and both uterine and rectal prolapse.[2,7,9,14]

The multisystem pattern which appears to be emerging points to a widespread disorder of connective tissue.[9] Since collagen provides the infrastructure on which the physical integrity of articular cartilage and extra-articular tissue depends, the answer may well lie here. Certainly a loss in the tensile strength of the connective tissue framework in the anterior abdominal wall and the pelvic floor could explain an increased liability to hernias, prolapse, and other consequences of tissue laxity. Although there have been many recent discoveries using molecular genetic techniques, the question remains as to which collagen is at fault.

Although no demonstrable hereditary disorder of the connective tissue can be recognized in the majority of individuals exhibiting generalized joint hypermobility, a small proportion have specific genetic conditions, such as Marfan syndrome, Ehlers-Danlos syndrome, and osteogenesis imperfecta. It is extremely difficult to diagnose mild forms of disorders of the connective tissue. It has been postulated that the hypermobility syndrome represents an overlap syndrome which incorporates some of the features seen in the heritable connective tissue disorders.[2,15]

The question of whether the temporomandibular joint shares in the condition of generalized joint hypermobility has not been adequately addressed.

Hypermobility of the mandible has been cited as a possible predisposing factor in the development of temporomandibular joint disorders.[3,8,16-18] It has also been suggested that generalized joint hypermobility may be related to the development of temporomandibular joint disorders.[19]

Measurement of the distance between the teeth during maximum mandibular movement has proven to be an inexpensive, convenient, and reliable assessment of temporomandibular mobility.[20] Measurement of maximum mandibular opening varies with age and gender in a way that is inconsistent with the flexibility tests for other joints. As previously noted, females tend to have more flexible joints than males at all ages, and flexibility decreases after childhood.[7] However, maximum jaw opening is less in women than in men, and increases from childhood to adulthood. Therefore, it can be argued that maximum mandibular opening appears to reflect jaw size (length) rather than flexibility.[16] It is also important to remember that internal derangement and muscular restrictions may reduce vertical opening and conceal laxity of the temporomandibular ligaments.[3]

Radiographic methods of evaluation are thought to be the most accurate, but are not used for epidemiologic purposes. The literature suggests that hypermobility may be indicated by a condylar position in front of the crest of the articular eminence on wide opening and condylar retroposition (posterior-superior) with the mouth closed.[3] Quantification of craniomandibular mobility has not been reported using an arthrograph, as designed earlier for the knee, elbow, and finger joints.[21] Temporomandibular joint patients demonstrate changes in the mobility of the range of mandibular movements either towards a hypo or hypermobile state. Currently, there is no unity of opinions concerning the borders of these conditions.

Schultz[3,19,22] introduced the concept of temporomandibular joint hypermobility to the dental literature in 1947 using palpation of these joints as a diagnostic tool. He noted its association with symptoms of stomatognathic dysfunction and pointed out that subluxation of the temporomandibular joint might be due to the effect of congenital weakness of the joint capsule. Boering[19] found no relationship between hypermobility of the temporomandibular joint measured on radiographs as excessive condylar translation, and hypermobility of the hand and elbow joints. However, he did notice a trend of increased temporomandibular joint mobility while examining patients with generalized joint hypermobility. Katzburg[3,19] found through arthrotomagraphic studies that patients who had temporomandibular joint disc displacement with reduction showed hypermobility, that is, greater condylar translation, on the symptomatic side.

Most clinical studies have focused upon the active range of mandibular movement. Angerburg[17] found significant correlation between maximum mandibular movement and mobility of the thumb, and with the finger spread between the index and little fingers. However, he concluded that the degree of maximum mandibular movement did not appear to appreciably depend on systemic factors associated with generalized hyper or hypomobility of joints. This study did not directly examine range of mandibular movement in subjects exhibiting systemic joint laxity. Also, the author assessed joint mobility in only three body joints on one side of the body, and then compared only individual body joint movement with maximum mandibular movement, rather than attempting to correlate mandibular movement with an overall joint mobility score.

Bates et al[18] found a highly significant correlation between wrist and elbow joint laxity and internal derangement of the temporomandibular joint for female subjects. Internal derangement was defined by presence of clicking or crepitus in the temporomandibular joint as exposed by palpation and auscultation with a stethoscope.[18] This investigation is flawed by the small number of subjects studied, the lack of clear diagnostic criteria for temporomandibular joint derangement, and the limited number of peripheral joints measured.

Greenwood[16] attempted to discover a link between hypermobile peripheral joints and the temporomandibular joint by correlating flexibility at the wrist joint with maximum mandibular opening. Results of his study failed to demonstrate any relationship between general joint mobility and maximum jaw opening.

Caution must be taken when interpreting the data from studies which test for systemic hypermobility at a few selective sites. Researchers have found that hypermobility at one site was not predictive of hypermobility at other sites. In order to adequately assess the connective tissue environment, multiple joint tests should be performed.[8]

Plunkett and West[17] assessed the general joint mobility and maximal mandibular active range of motion in subjects with generalized joint hypermobility and normal masticatory function and asymptomatic temporomandibular joint clicking. Furthermore, an attempt was made to determine suitable criteria for clinically determining mandibular hypermobility. Assessment for this study was based on anamnestic data, interviews, and clinical examination. Systemic joint flexibility was determined by the Beighton criteria, a modification of the Carter and Wilkinson hypermobility scoring system. The mean maximal opening for the males was 57.9 mm and for the females was 51 mm. The hypermobile subgroups consistently recorded the highest values for all mandibular movements in both sexes. Hypermobility score was found to be significantly correlated with maximum opening and left lateral movement in both sexes.

Plunkett and West[17] concluded that the mean vertical opening of the hypermobile subgroups could be used as a basis for clinically determining hypermobility of the mandible. Based on this study, a male maximal opening in excess of 65 mm and a female vertical opening in excess of 55 mm may be reasonable criteria for judging hypermobility of the mandible. Applying these criteria to the subjects in Plunkett and West's study reflects the acknowledged

3:1 female to male ratio seen in temporomandibular joint disorder patient groups.

Westling[3] also utilized Beighton's criteria to assess the peripheral joint mobility of patients referred to a clinic with a variety of craniomandibular disorders. This study showed a significantly higher prevalence of temporomandibular joint dysfunction among females with hypermobility of peripheral joints than in female craniomandibular patients without hypermobility. Westling concluded that generally increased joint mobility, not including the temporomandibular joint, should be considered as a predisposing factor in temporomandibular joint dysfunction. She felt that altered biomechanics due to laxity in temporomandibular joint capsules and ligaments leading to instability may increase the likelihood of joint injury. Thus special consideration should be given to patients with generalized hypermobility when performing craniomandibular disorder therapy and restorative dentistry, especially the prevention of excessive and prolonged mandibular opening.

In their study of the relationship between mandibular border positions and peripheral joint mobility, McCarroll et al[22] included tests of the passive mandibular border positions. The "end feel distance" was quantitatively defined as the distance measured between the passive and active ranges of mandibular motion.[22] In a healthy young population, the authors found that the female group had a significantly larger difference between the passive and active mandibular border position when compared with a male group matched for age.

This may reflect the fact that the joints of females are generally more elastic than male joints. These differences were also found in various peripheral joints. This increased mobility was best displayed in the passively measured joints, the thumb and fingers. Only a few weak correlations were found between the measurements of the different mandibular border positions and the peripheral joint mobility measurements.

Most interesting were the strong intra-individual correlations found in the male group when considering the different passive and active mandibular border positions. Weak or no intra-individual correlations were found in the female group which was interesting in light of the high incidence of female patients in the temporomandibular joint derangement group. From these findings, McCarroll et al[22] concluded that local factors are to be looked on as a more probable etiology in developing altered temporomandibular joint mobility, rather than being part of a generalized joint hypermobility. Plunkett and West[17] have questioned the findings of McCarroll et al[22] because of the study's use of a modification of the Carter and Wilkinson[5] system for assessing hypermobility. According to these authors, the new scoring system is inconsistent for the various joints tested, and fails to define at what score a subject may be considered as exhibiting systemic hypermobility.

Further investigation by Westling and Mattiasson[19] demonstrates the localized nature of symptoms in the hypermobility syndrome. In this study, the authors examined the correlation between the symptoms of temporomandibular joint dysfunction and several proposed etiologic factors including general joint mobility, sex, oral parafunction, and head and jaw trauma.

The significant correlations found between generalized joint hypermobility and early temporomandibular joint symptoms indicate a systemic influence in the etiology of temporomandibular joint dysfunction.[19] Unfavorable systemic factors, such as joint hypermobility, appear to play an important role when the masticatory system is exposed to local forces as in parafunction (bruxism, gum chewing, etc.) and trauma. For this reason, the condition may be under-recognized. It appears that micro or macrotrauma play an important role in determining which joints become symptomatic. This is indicated by the lack of correlation between parafunctions and joint sounds in the whole group, while significant correlations were found in the hypermobile group.[19]

A possible cause of the correlation between temporomandibular joint symptoms and generalized joint hypermobility is that the particular defect which contributes to peripheral joint laxity is identical to that which leads to internal derangement in the temporomandibular joint. If the fibroelastic tissue of the posterior disc attachment is in one state in the stiff-jointed and another in the hypermobile individual, then its effect on the temporomandibular joint disc will differ.[19]

In order to understand how hypermobility of the periarticular connective tissue may predispose the temporomandibular joint to dysfunction, we need to briefly review the physiology of this joint. The temporomandibular joint is classified as a synovial joint.[23] It may therefore be assumed that it is constrained against excessive movements by the same biomechanical principles as other synovial joints. There is little literature regarding the stability of the craniomandibular articulation other than those concerned with its relation to the surrounding capsule and ligaments. Therefore, it is unclear to what extent the degree of the slope of the articular eminence or the size and shape of the condyle contribute to the stability of the craniomandibular articulation. Likewise, there is a paucity of studies regarding the influence of the muscle activity on the mandible as a constraint against excessive joint motion.[21]

The connective tissue components of the temporomandibular joint serve a dual function; the periarticular tissue keeps the joint surfaces together and limits range of motion. Within the protective framework of the connective tissue are the highly vascularized synovials. The synovials are located at the end points of the temporomandibular joint. If the joint is excessively ranged, the mandibular head may invade the synovial territory and damage the delicate network of capillaries, lymphatics, and nerve fibers.[23]

In order to maintain the temporomandibular joint in a state of physiologic rest, the condyle must be placed in a concentric position in the joint. This position corresponds to the "loose packed position of the joint." In this position, the condyle rests in the fossa or slightly anterior facing the middle one-third of the articular eminence and the biconcave surface of the disc. In this functional position, the periarticular connective tissue is at 70-80% of its actual connective tissue length. Positions at the end ranges of mandibular motion are referred to as anterior and posterior close packed positions.[23]

In these close packed positions, the joint components are maximally congruent and the connective tissue is elongated to 100% of its length. In these extreme positions, no additional movement is possible. The anterior close packed position of the temporomandibular joint is assumed during maximum mandibular opening and is primarily constrained by the temporomandibular ligament and the lateral portion of the capsule.[21] The condyles are prevented from assuming the posterior close packed position by normal occlusal contact and by the presence of the pain producing neurovascular structures in the posterior joint space.[21,23]

If the connective tissue is repetitively stretched to 100% of its length, the periarticular structures will become loose and the joint will lose its normal synovial joint physiology. If the temporomandibular joint capsule and ligament undergo fatigue failure or if the viscoelastic properties are impaired by the presence of a defective collagen, the joint may become hypermobile. A hypermobile temporomandibular joint is characterized by excessive translatoric movement of the mandible. This condition may lead to an unstable disc which reacts inconsistently to the demands of mandibular function. For example, the patient may express difficulty in finding a comfortable mandibular rest position which induces abnormal movements for accommodation. This may also result in further ligamentous laxity and muscular imbalance.[23]

Generalized joint laxity manifested by a high score on the Beighton criteria may be suggestive of an abnormality in the collagen structure and may predispose affected joints to injury. Measurement of a group of joints with a simple scoring system may be a useful diagnostic tool if the criteria reflects the state of the connective tissue of most other joints in the body. Further investigation is warranted to determine a standardized system for quantifying systemic joint laxity and to define the criteria for hypermobility of the temporomandibular joint.

CHAPTER III

METHODS

Subjects

The subjects for this study were a class of second year physical therapy students. These students volunteered to participate in accordance with the guidelines established by the Institutional Review Board at the University of North Dakota. (Appendix A) Forty-seven students participated in the study, 28 (60%) were women and 19 (40%) were men. The ages ranged from 20 to 38 years, with a mean of 24 years (SD = 4.90). The students worked in pairs under supervision to measure and record: 1) the Beighton hypermobility criteria, 2) mandibular range of motion, and 3) a questionnaire of temporomandibular joint dysfunction and oral parafunctional habits.

Instrumentation

Beighton Criteria

The general joint mobility of each individual was assessed and graded according to the Beighton criteria.[2] This is a series of clinical tests derived by Beighton et al from the earlier system of Carter and Wilkinson.[5] (Fig. 1) A score of zero to nine is allocated to the subject, with one point awarded for the ability to perform each maneuver. The higher score indicates a greater degree of overall joint laxity. The level of the scoring scale at which the diagnosis of generalized joint hypermobility is assessed is arbitrary with the majority of

BEIGHTON TEST CRITERIA

1) passive dorsiflexion of the fifth metacarpophalangeal joint beyond 90° (one point for the right and one point for the left)

2) passive opposition of the thumbs to the flexor aspect of the forearm (one point for the right and one point for the left)

3) hyperextension of the elbows beyond ten degrees (one point for the right and one point for the left)*

4) hyperextension of the knees beyond ten degrees (one point for the right and one point for the left)*

5) forward flexion of the trunk with the knees fully extended so that the palms of the hands rest flat on the floor (one point)

Figure 1

*Range of motion of the elbows and knees was measured by standard goniometry as described by Norkin and White.[24]

clinicians requiring a minimum score of between 4/9 and 6/9. It has been suggested that in mobility studies which include different age groups, a mobility score of four or more may be utilized without bias.[2,8]

Although there is little data regarding the reliability of the Beighton criteria, there is one study which has examined the validity of this system. The Leeds group compared three different methods assessing joint laxity. The first method was the Beighton criteria. The second was the Leeds hyperextensometer, a devise which records the range of motion of the metacarpophalangeal joint of the index finger in response to a preset torque. The third technique was a global index which was derived by using goniometry to assess the range of motion at a majority of the joints in the body and then summating the measured arcs of movement. The global index was calculated by following the guidelines recommended by the American Orthopaedic Association (1965). This investigation indicated that the Beighton criteria correlated better than the hyperextensometer when matched against the "global index."[2]

Goniometric evaluation is widely accepted as the gold standard for the assessment of joint range of motion. Certainly, goniometry provides the simplest method for the assessment of range of motion at a hinge joint. However, properly positioning the instrument according to surface markers is difficult and time consuming. It is, therefore, this author's opinion that the Beighton criteria is the preferred method for rapid assessments of the type required in clinical screening and population studies.

Mandibular Motion

The students recorded mandibular range of motion utilizing the Therabite™* scale. (Appendix B) In the event that the subject's maximum mandibular range of motion exceeded the scale of the therabite, mandibular range of motion was recorded using a clear plastic goniometer as described by Norkin and White.[24]

Although the students did receive instruction in the techniques of the assessment of mandibular range of motion, their inexperience posed questions

*Therabite Corporation, 6 South Bryn Mawr Ave., Bryn Mawr, PA 19010 with regard to measurement reliability. Therefore, an additional set of data was collected in order to examine reliability and to ensure that this would not render the study invalid.

The class was divided into two equal groups of 23 testers and 23 subjects. The testers followed standardized procedures for the measurement of maximum mandibular opening. Each tester recorded three repeated measurements on two subjects. The intraclass correlation coefficients (ICC) were calculated to express the reliability of the measurements. The ICC value across repeated measures (intratester reliability) was .995, while the ICC values between testers was .979.

While no universally accepted levels have been adopted for correlation coefficients for the purpose of describing the reliability of measurements, we utilized a previously reported scheme[25] for the definition of the degree of reliability. According to this scheme, ICC values of .90 to .99 reflect high reliability; .80 to .89, good reliability; .70 to .79, fair reliability; and .69 and below, poor reliability. Thus, the reliability of the measurements obtained by the students, in spite of their inexperience, was high.

Questionnaire

Prior to the clinical examination, each participant received a self-administered questionnaire. The questions recorded the presence of some common symptoms of temporomandibular joint dysfunction and the awareness of oral parafunctional habits. The questions were derived from a study of the background factors in craniomandibular disorders by Westling and Mattiasson.[19] These questions were constructed to be answered "frequently, occasionally, or never." (Appendix C) Response to the questionnaire was measured by assigning a numeric score to each questions; zero for never, one for occasionally, and two for frequently. The score for each category represents a cumulative index for parafunction and for symptoms.

Data Analysis

The data analysis was accomplished using a computer software statistical package identified as SPSSX™.* The T-test for two independent samples was utilized to determine the differences in the mean values for mandibular opening, symptoms, parafunction, and peripheral mobility in both the male and female subgroups. The Pearson correlation coefficient was also calculated for the identified variables, with further statistical treatment of partial correlates controlling for gender.

*SPSSX™ Inc., 444 North Michigan Ave., Chicago, IL 60611

CHAPTER IV

RESULTS

The mean mobility score recorded for males was 1.21 and for females, 2.14. Twelve out of the 47 subjects (15.5%) had a Beighton score greater than or equal to four. Of this hypermobile subgroup, four were males and eight were females. Therefore, 21% of the males in this study were hypermobile and 29% of the females. Ranges, averages, and variability of the Beighton criteria are presented in Table 1.

Table 1.--Range and Average Values of the Beighton Criteria

	Number	Range	Mean	SD
All Subjects	47	0 - 8	1.7	2.3
All Males	19	0 - 6	1.21	1.93
All Females	28	0 - 8	2.14	2.53
All Hypermobile Subjects*	12	4 - 8	5.25	1.31
Hypermobile Males*	4	4 - 6	4.0	1.15
Hypermobile Females*	8	4 - 8	5.63	1.41

*Beighton score ≤ 4

The range of maximal mandibular opening for all subjects was 35 to 73 mm, with a mean of 53.68 mm (SD = 7.84 mm). The mean maximal opening for males was 58.00 mm and for females was 50.75 mm. The mean mandibular opening of the four systematically hypermobile men was 61 mm, while the mean opening of the eight systematically hypermobile women was 54 mm. (Table 2)

Table 2.--Range and Average Values of Mandibular Opening

	Number	Range(mm)	Mean(mm)	SD
All Subjects	47	35 - 73	53.68	7.84
All Males	19	48 - 70	58.0	6.67
All Females	28	35 - 73	50.75	7.29
All Hypermobile Subjects*	12	35 - 73	56.33	11.11
Hypermobile Males*	4	60 - 70	61.0	7.39
Hypermobile Females*	8	35 - 73	54.0	2.32

*Beighton score ≤ 4

The mean maximum opening of all patients with hypermobile mandibular opening, that is, opening in excess of 65 mm for males and 55 mm for females, was 65.57 mm (SD = 6.27). The mean opening for males with hypermobile mandibular opening was 68.3 mm (SD = 2.08). The mean Beighton score of this group was 2.0 (SD = 3.46). The mean maximum opening of the females with hypermobile mandibular opening was 63.5 mm (SD = 7.89). The mean Beighton score was 6.5 (SD = 1.29).

The T-test for independent samples revealed that males have a greater maximal opening of the mandibular which was significant at the .05 level. (Table 3)

Table 3.--Results of T-test for Variables of Gender and Maximum Mandibular Opening

	Number	Mean	SD	T Value*	df	two-tailed probability
Males	19	58.00	6.66	3.46	45	.001
Females	28	50.75	7.29			

*The T values were calculated from the pooled variance estimates.

Calculation of the Pearson correlation coefficient for the variables of mandibular opening, symptoms, parafunctional habits, and generalized mobility reveals a strong correlation between gender and the maximum mandibular open values (P = .001). (Table 4)

Table 4.--Pearson Correlation Coefficients of Mandibular Opening with all Other Independent Variables

Mandibular Opening With	r value	Significant Level
Gender	-.4585	p = .001
Symptoms	-.1622	p = .276
Habits	-.2566	p = .082
Mobility	.2191	p = .139
Age	-.2459	p = .096

Because of the strong relationship identified between gender and maximum mandibular opening, a partial correlation was performed controlling for gender. (Table 5) The adjusted data indicated that generalized joint hypermobility is positively correlated with maximum mandibular opening at the .05 level (p = .008). It also revealed that oral parafunctional activities are inversely correlated to maximum opening (p = .039). This analysis also noted a negative relationship between the temporomandibular joint symptoms and mandibular opening, but this was not statistically significant (p = .056).

Table 5.--Partial Correlation Coefficients of Mandibular Opening with Other Independent Variables when Controlling for Gender

Mandibular Opening With	r Value	Significant Level
Mobility	.3559	p = .008
Parafunction	-.2622	p = .039
Symptoms	-.2337	p = .056

A score of one to four on the parafunction scale was obtained by 72.3 percent of the subjects. The mean score was 3.6, and the standard deviation was 1.7. The percentage distribution of reported oral parafunction is listed in Table 6.

Table 6.--Percentage Distribution of Oral Parafunctions Reported

Are you aware of?	All Subjects n = 47	Systematically* Hypermobile Subgroup n = 12	Mandibular** Hypermobile Subgroup n = 7
Gum chewing			
occasionally	44.7	41.7	42.9
frequently	48.9	58.3	42.9
Biting your cheeks, lips, or tongue			
occasionally	48.9	50.0	28.6
frequently	10.6	16.7	14.3
Nail biting			
occasionally	40.4	33.3	14.3
frequently	8.5	--	--
Tooth clenching			
occasionally	38.3	50.0	28.6
frequently	8.5	--	--
Tooth grinding in daytime			
occasionally	6.4	8.3	--
frequently	6.4	--	--
Tooth grinding in sleep			
occasionally	8.0	16.7	14.3
frequently	2.1	--	--

* Beighton score ≤ 4
**Maximum mandibular opening > 55 mm for females, > 65 mm for males

Sixty-six percent of the subjects had a score of zero or one on the symptoms scale. The mean score was 1.6 and the standard deviation was 1.7. The percentage distribution of temporomandibular joint symptoms is listed in Table 7.

Table 7.--Percentage Distribution of Temporomandibular Joint Symptoms

	All Subjects n = 47	Systematically* Hypermobile Subgroup n = 12	Mandibular** Hypermobile Subgroup n = 7
Do you have any of the following symptoms?			
Difficulty in opening the mouth wide			
occasionally	10.6	16.7	14.3
frequently	6.4	8.3	--
Pain on movement of the jaw			
occasionally	23.4	41.7	42.9
frequently	2.1	--	--
Tiredness during chewing			
occasionally	46.8	50.0	57.1
frequently	6.4	8.3	14.3
Joint sounds			
occasionally	27.7	16.7	14.3
frequently	10.6	16.7	14.3
Locking of the mandible (closed)			
occasionally	6.4	8.3	14.3
frequently	--	--	--
Locking of the mandible (open)			
occasionally	4.3	--	--
frequently	--	--	--

* Beighton score ≤ 4
**Maximum mandibular opening > 55 mm for females, > 65 mm for males

CHAPTER V

DISCUSSION

The results of the joint mobility tests confirm previous research which found that females are generally more "loose jointed" than males at any age.[2,7] The mean mobility scores recorded for males (1.2) and females (2.1) are similar to those previously reported.[17,26] In a study of similar design, Plunkett and West[17] recorded mean Beighton scores of 1.9 for males and 2.1 for females in a population of dental students aged 18 to 35 years old. The incidence of generalized joint laxity in the population under study was 15.5%. There were twice as many females (8) in the systemically hypermobile group as males (4). The mean Beighton score of the hypermobile males was 4.0 and the mean score of the females was 5.6. When grouped according to gender, 21% of the males were systemically hypermobile and 29% of the females. The Plunkett and West[17] study found an incidence of 19% in both sexes. Nicholas[27] found that 28% of 139 professional football players could be considered hypermobile. Beighton's[26] study of an African population found that 12% of the adult males and 32% of the adult females had a mobility score of three or more. If this lower criteria for systemic hypermobility was imposed on the population under study, 26% of the males would be considered hypermobile and 39% of the females.

Analysis of the mandibular range of motion indicated that males have a greater maximum opening of the mandible ($p < .05$). This may be attributable to the greater jaw length found in male subjects.[16] The mean maximum opening for males was 58.0 mm and for females was 50.75 mm. Plunkett and West[17] found the mean maximum opening to be 57.9 mm for males and 51.0 mm for females. The manufacturer of the Therabite™ scale recommend a normal maximum opening of 58 mm for males and 53 mm for females.[28]

Because gender was so strongly related to maximum opening, partial coefficients were calculated controlling for gender. This indicated a clear relationship between the Beighton criteria and maximum mandibular opening ($p = .008$). The mean mandibular opening of the four hypermobile men was approximately 61 mm and the mean opening of the women was 54 mm. When the mandibular hypermobility standard suggested by Plunkett and West of maximum opening in excess of 65 mm for men and 55 mm for women was applied to the population under study, four women (14.2%) could be considered hypermobile and three of the men (15.7%). If, in turn, this standard was applied to the systemically hypermobile subgroup, 50% of the women also exhibited hypermobility of the mandible compared to 25% of the men. The mean Beighton score of the males with hypermobile mandibular opening was 2.0 and the females 6.5. These results suggest a significant correlation between generalized joint hypermobility as measured by the Beighton criteria and hypermobility of the mandible in the vertical plane of movement.

Maximum mandibular opening is considered to be one of the two "close packed" positions of the temporomandibular joint.[23] In this extreme position, no additional volitional movement is possible as the condyles have translated to the most anterior position on the articular eminence, the articular components are maximally congruent and the capsule and ligaments are taut. The lateral portion of the joint capsule and the temporomandibular ligament are the primary biomechanical constraints in this position.[21] If these connective tissue structures are abnormally lax, they may allow an excessive amount of mandibular opening and the posterior attachment of the disc may be overstretched. This may lead to fatigue failure of the posterior disc attachment and the position of the disc on the mandibular head may be altered.[23]

Excessive anterior translation of the mandibular head during opening may also create a peripheral neuropathy in the posterior neurovascular system of the temporomandibular joint. As the mandibular head glides anteriorly on the articular eminence, the posterior ligaments and capsule are stretched and the intrajoint pressure is increased. Because of the oblique relationship of the mandibular heads to the cranium, a repetitive strain injury may also occur in the lateral collateral ligaments.[23]

Excessive mandibular opening may also result in dislocation of the mandibular head over the articular eminence. In these cases of "open locking," the mandibular head travels over the apex of the articular eminence and is lodged under the angle produced by the zygomatic arch and malar bone. In this condition, the condyle and disc are outside their physiologic and anatomic range and can only be returned by an outside force.[23,29]

The relationship between the disc and the mandibular head may also be adversely affected by ligamentous laxity. In these cases, the disc progressively subluxes medially and anteriorly over the mandibular head. Eventually the condyle adopts a posterior-superior position when the mouth is closed and begins to encroach on the posterior functional space. The alteration in the position of the mandibular head leads to gradual elongation of the posterior attachment of the connective tissue to the disc. Repetitive overstretching of the connective tissue leads to fatigue failure of the collagen fibers and the ligaments may be rendered non-functional. If this occurs, the disc-mandible relationship will not reduce spontaneously and the condition will progress. Ultimately, this dysfunctional relationship will result in a loss of vertical dimension, degenerative changes and varying degrees of mandibular hypomobility.[23]

For these reasons, the author expected to find a positive relationship between generalized joint hypermobility and maximum mandibular opening. Furthermore, the author hypothesized that there would be a positive relationship between generalized joint mobility and/or mandibular hypermobility and the presence of some common temporomandibular joint symptoms. This relationship was not in evidence in this population.

The work of Westling and Mattiasson[19] suggested a correlation between generalized joint hypermobility and temporomandibular joint dysfunction when the temporomandibular joint is exposed to the local forces created by parafunctional oral habits. With this in mind, the author sought a similar relationship. This relationship was not found, but a significant negative relationship between maximum mandibular opening and parafunctional habits was discovered ($p = .039$).

Oral parafunctional activities, such as clenching and bruxism, have been implicated by many investigators as one of the primary etiologies of temporomandibular joint dysfunction.[30] In the population under study, 72.3% of the subjects received a score of one to four on the parafunctional scale. The mean score was 3.6 ($SD = 1.7$). The oral parafunction most frequently reported was gum chewing (48.9% of all subjects reported frequent gum chewing).

Parafunctional habits may lead to decreased mandibular opening by affecting 1) the dental occlusion (such as abrasive wear and hypermobility of the teeth), 2) the temporomandibular joint (adaptive remodeling of the joint in response to overload and by discal-muscular imbalance), 3) the neuromuscular system (muscular pathologies of various degrees from myospasm to fibromyalgia), and 4) the cranial-cervical system.[23] The last three of these etiological factors in temporomandibular joint dysfunction are commonly treated by physical therapists.

Several studies[29,30] have documented the relationship between parafunctional habits and hyperactivity of the muscle of mandibular elevation. It has also been established that muscle hyperactivity and/or muscular incoordination may result in adaptive changes in mandibular movement and positioning.[23,29,30] An example of this is the excessive muscle activity which results from frequent gum chewing. During chewing, the superior head of the lateral pterygoid muscle contracts in conjunction with the muscles of mandibular elevation. If the lateral pterygoid muscle becomes hyperactive or incoordinated, it may pull the disc anteromedially and overload the lateral collateral ligament. If the collateral ligament becomes elongated, the disc will become displaced in an anterior-medial direction.[31] The result of a dysfunctional disc-condyle relationship may be decreased anterior translation of the condyle and therefore reduced jaw opening.[23]

The sustained muscle contraction which accompanies parafunctional habits, such as clenching and bruxism, may lead to uncoordinated joint function as well as muscular pathology.[23,29,30] During normal muscle contraction, the muscle tissue suffers an episodic decrease in blood supply. In cases of repetitive sustained isometric contraction over an extended period of time, the irrigation of the muscle is altered. Diminished blood flow leads to ischemia and altered cellular metabolism. The subsequent accumulation of catabolites irritates the free nerve receptors and causes pain. The central nervous system responds to the painful stimuli with muscle contraction. This leads to the vicious cycle of pain-spasm-pain. Over time, this condition progresses to muscle contracture and results in decreased opening of the mouth.[23,32]

Parafunctional activities also affect the orthostatic position of the head.[23] An example of this may be seen in nail biting. During this activity, the mandibular position is relatively fixed and the cranium moves to the mandible. Therefore, the muscles which posteriorly rotate the cranium are activated as antagonists (i.e., the suboccipitals and sternocleidomastoideus), and the cranium posteriorly rotates in relation to the occiput. When the head moves posteriorly, the mandible drops down and backwards and the mandibular rest position is altered. In order to balance this new position of the mandible, the muscles which elevate the mandible become hyperactive. Therefore, parafunctional activities may facilitate posterior cranial rotation and a forward head posture.[33] This, in turn, sets the stage for the problems associated with hyperactivity of the muscles of mastication.

CHAPTER VI

CONCLUSION

The results of this study indicate a significant relationship between systemic joint hypermobility as measured by the Beighton criteria and maximum mandibular opening. This implies that there is a need to reevaluate the criteria by which mandibular mobility is assessed. Mandibular hypomobility in the vertical plane is widely accepted as being jaw opening of less than 40 mm.[17] Practitioners need to recognize that this criteria may be inappropriately low for patients who exhibit systemic joint hypermobility. It is conceivable that these subjects could exhibit 40 mm of opening despite a severe limitation of their maximal opening capacity.

Most authors[2] agree that it is easier to measure movement at a single joint than at multiple sites. The metacarpophalangeal joints have been utilized in several studies[2] using mechanical devices because they are easily accessible and exhibit a wide variation in range of motion in a normal population. However, the information obtained from the study of a selected joint is only useful if that joint can be shown to mirror the status of the majority of other joints in the body. If joints of comparable size and anatomical structure are compared, the extrapolation has theoretical attractions. Mariano Rocabado, PT, suggests that the practitioner should qualitatively test the ligamentous laxity of the first metacarpophalangeal joint prior to examination of the temporomandibular joint.[23] Further investigation is warranted to examine the relationship between the mobility of the first metacarpophalangeal joint and the temporomandibular joint.

The study did identify a significant negative relationship between maximum mandibular opening and the presence of some common oral parafunctional habits. It is clear that parafunctional activities which involve habitual elevator muscle hyperactivity have the potential for severe overload on the teeth, the temporomandibular joint, and the neuromuscular structures. In the presence of frequent microtrauma, damage to some part of the masticatory system seems almost inevitable.[30]

APPENDIX A

UNIVERSITY OF NORTH DAKOTA'S
INSTITUTIONAL REVIEW BOARD

DATE: April 14, 1992

NAME: Ted Thomas **DEPARTMENT/COLLEGE** Physical Therapy

PROJECT TITLE: Generalized Joint Hypermobility and Maximal Mandibular Opening

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on 4/14/92 and the following action was taken:

[X] Project approved. **EXPEDITED REVIEW** NO. 3.
Next scheduled review is on April 1993.

[ ] Project approved. **EXEMPT CATEGORY** NO. _____. No periodic review scheduled unless so stated in REMARKS SECTION.

[ ] Project approval **deferred.**
(See REMARKS SECTION for further information.)

[ ] Project **denied.**
(See REMARKS SECTION for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

Well written!

c: H. Wessman, Adviser
Dean, Graduate School

Elvira Szigeti 4/14/92

Signature of Chairperson or designated IRB Member — Date
UND's Institutional Review Board

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 596 Form may be required. Contact ORPD to obtain the required documents. (9/87)

___EXPEDITED REVIEW REQUESTED UNDER ITEM _____ (NUMBER[S]) OF HHS REGULATIONS
___EXEMPT REVIEW REQUESTED UNDER ITEM _______ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

INCIPAL
VESTIGATOR: Ted Thomas TELEPHONE: (218)281-1312 DATE: 4-6-92

DRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: 132½Mill St Crookston MN 56716

HOOL/COLLEGE: Medicine DEPARTMENT: Physical Therapy PROPOSED PROJECT DATES: April 23, 1992

OJECT TITLE: Generalized Joint Hypermobility and Maximal Mandibular Opening

NDING AGENCIES (IF APPLICABLE): none

PE OF PROJECT:
___ NEW PROJECT ___ CONTINUATION ___ RENEWAL ___ DISSERTATION OR THESIS RESEARCH ___ STUDENT RESEARCH PROJECT

___ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

SSERTATION/THESIS ADVISER, OR STUDENT ADVISER: H.C. Wessman

OPOSED PROJECT: ___ INVOLVES NEW DRUGS (IND) ___ INVOLVES NON-APPROVED USE OF DRUG ___ INVOLVES A COOPERATING INSTITUTION

ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

_ MINORS (<18 YEARS) ___ PREGNANT WOMEN ___ MENTALLY DISABLED ___ FETUSES ___ MENTALLY RETARDED

_ PRISONERS ___ ABORTUSES X UND STUDENTS (>18 YEARS)

YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL TERIALS, CHECK HERE _______

ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

Joint hypermobility is an important concept in the practice of physical medicine ecause excessive joint laxity has been implicated in a wide variety of articular omplications. Clinical observations led Kirk et al, to define the "hypermobility yndrome" in a group of patients with generalized joint laxity and musculoskeletal omplaints in the absence of demonstrable systemic rheumatologic disease. Recent tudies have suggested a possible association between temporomandibular joint ysfunction and generalized joint hypermobility.

Measurement of mandibular motion is regarded as one of the most objective means f determining the extent of temporomandibular joint dysfunction. A high degree of orrelation between restricted mandibular motion and the various signs and symptoms f temporomandibular joint dysfunction has been found. However, the opposite phenomenon, ypermobility, may be as detrimental as hypomobility.

The purpose of this study is to determine whether people with generalized oint hypermobility also demonstrate hypermobility at the temporomandibular joint. urthermore, an attempt will be made to determine whether these individuals are ore likely to exhibit the clinical signs of temporomandibular joint dysfunction.

.EASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

. **PROTOCOL:** (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

Subjects:

The subjects for this study will be a class of second year physical therapy students at the University of North Dakota. The data will be collected during the laboratory session of PT 419, Muscle Function in Health and Disease. Prior to the laboratory session the students will receive an hour of lecture on the temporomandibular joint and generalized joint hypermobility.

Methods:

The students will work in pairs under supervision to measure and record the following: 1) the Beighton hypermobility criteria, 2) Maximum mandibular opening, 3) A questionnaire of temporomandibular dysfunction.

The joint mobility of each individual is to be assessed and graded by means of the Beighton criteria. This is a series of clinical tests to assess the range of articular movement. Scores are given from zero to nine with one point awarded for the ability to perform each test. The scoring system is as follows:

a) passive dorsiflexion of the fifth metacarpophalangeal joint beyond 90°
(one point for the right and one point for the left)
b) passive opposition of the thumbs to the flexor aspect of the forearm
(one point for the right and one point for the left)
c) hyperextension of the elbows beyond ten degrees
(one point for the right and one point for the left)
d) hyperextension of the knees beyond ten degrees
(one point for the right and one point for the left)
e) forward flexion of the trunk with the knees fully extended so that the palms of the hands rest flat on the floor. (one point)

The hyperextension of the elbows and knees will be measured by goniometry, see attached. Individuals who perform four or more of these maneuvers are to be considered hypermobile.

The students will record the maximum mandibular opening utilizing the therabite range of motion scale, see attached.

Prior to the clinical examination, each participant will receive a self-administered questionnaire. The questions will record the presence of some common symptoms of temporomandibular joint dysfunctions and awareness of oral parafunctions. These questions are constructed to be answered, "frequently, occasionally or never", see attached.

BENEFITS: (Describe the benefits to the individual or society.)

1) Establishing the importance of generalized joint hypermobility and/or temporomandibular joint hypermobility in the etiology of temporomandibular joint dysfunction.

2) Recognition that the criteria by which hypomobility of the mandible is assessed may be inappropriately low for subjects with generalized joint hypermobility.

3) Recognition that the patient with hypermobile joints may require special precautions when undergoing temporomandibular joint therapy and restorative dentistry.

RISKS: (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

The potential risks of participation in this research project are minimal. The procedures utilized are noninvasive and are routinely employed in the clinical evaluation of joint laxity and temporomandibular function.

Information and Consent Form

Generalized Joint Hypermobility and Maximum Mandibular Opening

You are being invited to participate in a study being conducted by Ted Thomas, PT in fulfillment of the independent studies requirement of the Masters of Physical Therapy degree at the University of North Dakota. The purpose of this study is to determine whether people with generalized joint hypermobility also demonstrate hypermobility at the temporomandibular joints. The information gathered from this study will be useful to physical therapists treating temporomandibular disorders.

The data will be collected during the laboratory session of PT 419, Muscle Function in Health and Disease. Prior to this laboratory session, you will receive instruction in the subjects of generalized joint hypermobility and the temporomandibular joints. The procedures utilized are widely accepted, non-invasive clinical evaluation techniques.

Your name will not be used in any reports of the results of this study, and all data will be kept strictly confidential. If you decide to participate, you are free to discontinue participation at any time without prejudice. Participation in this study is not a requirement of PT 419, and will in no way affect your class standing. Any questions you may have regarding this study will be answered by Ted Thomas PT or by your course instructors, Erin Simmons or Tom Mohr.

I have read the above description of the research project entitled, "Generalized joint hypermobility and maximum mandibular opening". I understand the procedures and possible risks associated with this study. I further understand that any questions I may have regarding this study will be answered, and that I will not be personally identified in any reports of this study. I understand that I may discontinue participation in this project at any time without prejudice to myself. My signature indicates that having read the above information, I agree to participate in this research project.

____

Print Name

________________________________ ________________________

Signature Date

. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

The consent forms will be retained for a period of one year. They will be stored with the administrative records at the University of North Dakota, School of Medicine, Department of Physical Therapy.

. For **FULL IRB REVIEW** forward a signed original and twelve (12) copies of this completed form, and where applicable, twelve (12) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Box 8138, University Station
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

- -

ıe policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use f Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are ɔ be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use f human subjects.

IGNATURES:

______________________________ **DATE:** ____________________
·incipal Investigator

______________________________ **DATE:** ____________________
·oject Director or Student Adviser

______________________________ **DATE:** ____________________
·aining or Center Grant Director

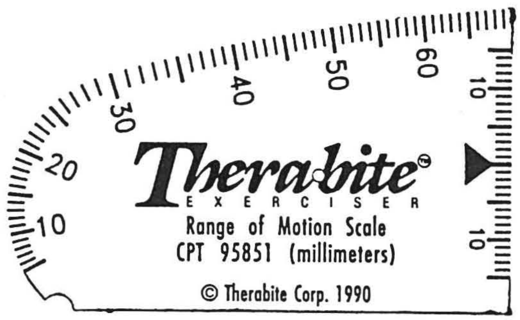
(Revised 7/1990)

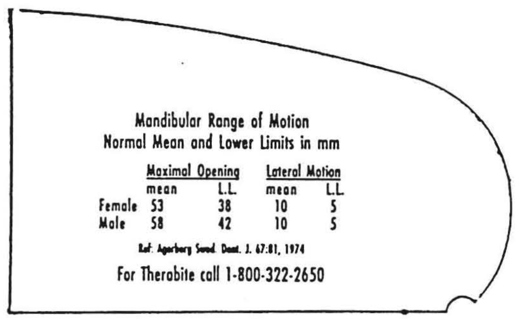
APPENDIX B

low To Use the Therabite® EXERCISER

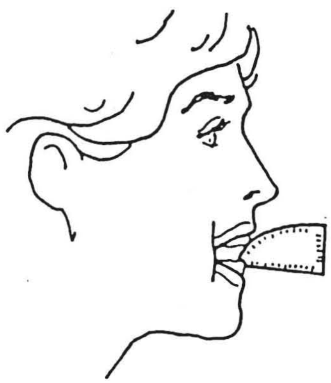
Range of Motion Scale

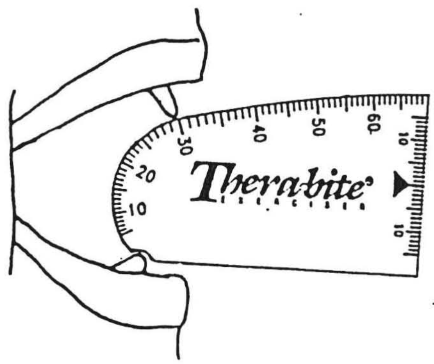
This handy disposable scale makes mandibular motion measurement quick and easy. Normal values and lower limits are printed on the reverse side. CPT code 95851 covers insurance reimbursement for range of motion measurement and treatment.



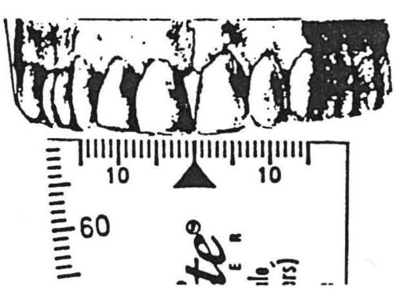


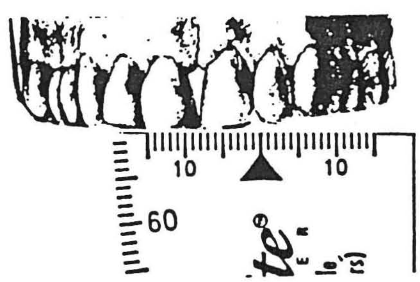
For **Maximal Incisal Opening**, have the patient open as wide as possible. Rest the notch on the edge of a lower incisor. Rotate the scale until it contacts an upper incisor. Take the reading at the point of contact. The reading on this patient is 29.5 mm. For easy reading, the scale is expanded in the range from 25 to 45 mm.





For **Lateral Motion**, rest the scale against the lower incisors with the teeth in gentle occlusion. Align the arrow with an interproximal space. Have the patient move the madible laterally, and read motion on the scale opposite the new position of the space. This patient has a right lateral motion of 8 mm.





all us at 1-800-322-2650, or write us at **Therabite Corporation**
6 South Bryn Mawr Ave.
Bryn Mawr, PA 19010

APPENDIX C

GENERALIZED JOINT HYPERMOBILITY AND MAXIMUM MANDIBULAR OPENING

Age _____ Sex _____ Naid No. __________

o you have any of the following symptoms?

	Never	Occasionally	Frequently
Difficulty in opening mouth wide	_____	_____	_____
Pain on movement of the jaw	_____	_____	_____
Tiredness during chewing	_____	_____	_____
Joint sounds (clicking)	_____	_____	_____
Locking of the mandible (closed)	_____	_____	_____
Dislocation of the mandible (open)	_____	_____	_____

re you aware of?

Gum chewing	_____	_____	_____
Biting your cheeks, lips or tongue	_____	_____	_____
Nail biting	_____	_____	_____
Tooth clenching	_____	_____	_____
Tooth grinding in the daytime	_____	_____	_____
Tooth grinding in your sleep	_____	_____	_____

obility rating

	Right		Left
Fifth MPJ Ext. 90°	_____		_____
Opposition of thumb to forearm	_____		_____
Hyperext. of elbows 10°	_____		_____
Hyperext. of knees 10°	_____		_____
Forward trunk flex., palms to floor		________	
Total - General mobility rating		________	

andibular ROM in mm.

Maximum opening __________

Lateral excursion __________

Protrusion __________

APPENDIX D

RAW DATA

Number	Age	Gender	Symptoms	Parafunction	Beighton Score	Jaw Opening in mm
1	22	F	0	5	5*	50
2	32	F	1	3	1	51
3	29	M	1	6	0	48
4	21	F	4	4	0	53
5	23	M	1	4	0	60
6	24	F	0	3	0	49
7	23	F	3	5	2	52
8	30	M	3	3	0	53
9	32	M	2	4	1	57
10	21	F	1	0	3	49
11	22	F	0	5	4*	50
12	24	F	4	5	6*	57**
13	38	M	1	2	0	51
14	22	M	2	4	0	64
15	23	M	3	2	0	51
16	21	F	0	4	8*	67**
17	22	M	1	6	0	61
18	22	M	3	4	4*	60
19	21	F	1	2	1	54
20	25	F	5	2	6*	35
21	22	F	2	4	0	53
22	22	F	4	6	0	45
23	34	M	6	2	3	53
24	34	F	0	5	3	52
25	38	F	7	9	0	42
26	23	F	0	3	0	48
27	36	M	1	4	0	48
28	22	F	0	3	4*	43
29	21	F	5	4	7*	57*
30	22	F	0	1	5*	73**
31	21	M	1	3	6*	70**
32	22	F	1	3	0	52
33	23	F	0	2	0	51
34	24	M	1	2	0	69**
35	22	F	1	1	3	54

RAW DATA (Continued)

Number	Age	Gender	Symptoms	Parafunction	Beighton Score	Jaw Opening in mm
36	21	M	3	5	4*	52*
37	20	F	1	2	0	47
38	22	F	0	4	0	47
39	23	F	1	5	0	50
40	21	F	0	8	0	42
41	21	M	0	6	0	58
42	20	M	1	1	4*	62
43	26	M	1	4	0	57
44	22	F	0	3	1	46
45	21	M	3	3	1	62
46	22	M	1	2	0	66**
47	24	F	1	3	1	52

* Considered systemically hypermobile as defined by a Beighton score 4

**Considered as demonstrating mandibular hypermobility as defined by maximum mandibular opening > 55 mm for females and > 65 mm for males

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